

DETERMINATION OF RELATIONSHIP BETWEEN THICKNESS OF BASE COURSE AND DIFFERENT PHYSICAL PROPERTIES OF BASE MATERIAL IN THE CONSTRUCTION OF FLEXIBLE PAVEMENT

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ABSTRACT

The efficiency of flexible pavements depends mainly on the engineering properties of base course material. One of the most common tests used for designing pavement thickness is the California Bearing Ratio (CBR) test. The CBR test is costly and time-consuming. This research paper aims to study the relationship between the thickness of the base course material and various physical properties such as Los Angeles Abrasion (LAA), Aggregate Impact Value (AIV), Plasticity Index (PI), Maximum Dry Density (MDD), and Optimum Moisture Content (OMC). Samples of twenty different materials for the base course were collected from different parts of Nepal and then tested in the laboratory following SSRBW 2016 and related IS codes. The relationship between the values of CBR and different physical properties was established using regression analysis. Additionally, the relationship between base course thickness and physical properties was also analyzed using regression analysis. Strong correlations were observed between CBR, LAA, AIV, and PI. The following regression model was developed for estimating the value of CBR:

$$\text{CBR} = 131.625 - 0.59(\text{LAA}) - 0.963(\text{AIV}) - 0.804(\text{PI})$$

with an R^2 value of 0.881. Similarly, the relationship for predicting base course thickness was:

$$\text{Thickness (cm)} = -2.223 + 0.02(\text{LAA}) + 0.441(\text{AIV}) + 0.136(\text{PI})$$

with an R^2 value of 0.76. The developed models can be used for preliminary estimation of CBR and pavement thickness, thereby reducing testing time and construction costs.

KEYWORDS: Flexible pavement, Base course, CBR, LAA, AIV, PI, Pavement thickness, Regression analysis.

1. INTRODUCTION

Road transport plays an essential part in the socio-economic development of developing nations like Nepal. The predominant use of flexible pavements in roads can be attributed to economic reasons and easy construction. The efficiency of flexible pavement construction and the performance of these pavements are greatly affected by the characteristics of pavement materials, especially the base course materials.

The California Bearing Ratio (CBR) test is often employed to assess the characteristics of materials in order to ascertain appropriate pavement thickness. But soaked CBR testing is relatively time-consuming and laborious. Hence, finding some sort of correlation between CBR and readily available physical properties such as LAA, AIV, PI, MDD, and OMC could be more advantageous and less costly.

Prior research on this issue has primarily centered on the correlation between CBR value and particular properties of aggregates. Few attempts have been made to correlate base course thickness to combined properties of aggregates. This research seeks to fill that gap by formulating models for CBR value prediction and determining the thickness of the base course using aggregate properties.

2. Objectives of the Study

The primary goals of this study include:

1. Identifying the appropriateness of selected materials for base course construction based on SSRBW 2016.
2. Establishing correlations between CBR and physical parameters like LAA, AIV, PI, MDD, and OMC.
3. Finding correlations between base course thickness and physical parameters of base materials.
4. Developing regression models for predicting pavement thickness.

3. LITERATURE REVIEW

A number of scientists have tried correlating CBR values with index and aggregate characteristics. Research conducted by Shirur and Hiremath (2014), Rakaraddi and Gomarsi (2015), and Alawi and Rajab (2013) demonstrated a strong correlation between CBR and characteristics like PI, OMC, MDD, and LAA.

The relation between the thickness of the base course and LAA values was established by Uprety and Tamarakar (2017) through the use of IRC CBR design approach. Previous researchers had not adequately examined the combined effect of LAA, AIV, and PI on pavement thickness. This research expands on previous research through the establishment of various MLR equations that involve many physical properties at once.

4. METHODOLOGY

4.1 Sample Collection

Twenty samples of base course materials were collected from different quarry and river sources across Nepal. The sampling locations represented various geological regions and commonly used construction material sources.

4.2 Laboratory Tests

The following laboratory tests have been performed as per IS standards and SSRBW requirements:

- Los Angeles Abrasion Test (LAA)
- Aggregate Impact Value Test (AIV)
- Atterberg Limits Test
- Modified Compaction Test (MDD and OMC)
- California Bearing Ratio Test (CBR)

4.3 Data Analysis

The simple and multiple regression analysis was done using the statistical tool SPSS. Regression equations were formulated for finding out:

- Correlation between CBR value and physical properties
- Correlation between base course thickness and physical properties

The significance of the above equations was tested through:

- Coefficient of Determination (R^2)
- P-Value

- Mean Absolute Percentage Error (MAPE)

5. RESULTS AND DISCUSSION

5.1 Suitability of Base Materials

Results from the laboratory analysis revealed that the obtained samples met the criteria set for base course materials in SSRBW 2016. These criteria were as follows:

- CBR: 80-105%
- LAA: 22-39%
- AIV: 12-26%
- PI: 0.3-6%

From the analysis above, it was evident that the collected materials would be.

5.2 Relationship between CBR and Physical Properties

5.2.1 CBR and LAA

A strong negative relationship was observed between CBR and LAA:

$$\text{CBR} = 131.923 - 1.361(\text{LAA})R^2 = 0.75$$

The result indicates that increasing abrasion value decreases the bearing strength of the material.

5.2.2 CBR and AIV

The regression model between CBR and AIV was:

$$\text{CBR} = 127.898 - 1.84(\text{AIV})R^2 = 0.782$$

The relationship demonstrated that impact resistance significantly influences the strength of pavement materials.

5.2.3 Multiple Linear Regression Model

The best-fit regression equation obtained from multiple regression analysis was:

$$\text{CBR} = 131.625 - 0.59(\text{LAA}) - 0.963(\text{AIV}) - 0.804(\text{PI})R^2 = 0.881$$

The high R^2 value indicates that approximately 88.1% of the variation in CBR can be explained by the selected independent variables.

5.3 Relationship between Thickness and Physical Properties

The relationship developed between thickness of base course and physical properties was:

$$\text{Thickness (cm)} = -2.223 + 0.02(\text{LAA}) + 0.441(\text{AIV}) + 0.136(\text{PI})R^2 = 0.76$$

The regression model indicates that increases in LAA, AIV, and PI values require increased base course thickness to maintain pavement performance.

6. Validation of Regression Models

Five other samples from various sources were tested using the developed regression models to verify their validity. There was a strong correlation between the estimated results and those obtained through laboratory experiments. The Mean Absolute Percentage Error (MAPE) was satisfactory.

It can thus be concluded that the developed regression models can be successfully applied for pavement design and evaluation of materials quality.

7. CONCLUSION

This research was able to identify relationships among the thickness of the base course and several physical characteristics of the base materials in the flexible pavements. The main findings include:

1. All selected base courses met SSRBW specifications in 2016.
2. There is a strong inverse relationship between CBR and LAA, AIV, and PI.
3. Multiple linear regression model was more accurate than the simple linear regression model.
4. The developed equations can be utilized in predicting CBR value and thickness of pavement.
5. The equations can be used in reducing the frequency of CBR tests.

6. RECOMMENDATIONS

1. The derived relations must be considered for initial assessment and verification purposes only.
2. Further investigations are required using larger sample sizes and varied geology.
3. Other physical parameters like the flakiness index and moisture content can be studied in future.
4. Similar analysis needs to be performed for heavier loads and pavement sections.

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